



**CSC**

# APPLICATION OF PROCESS MODELING TOOLS TO SHIP DESIGN

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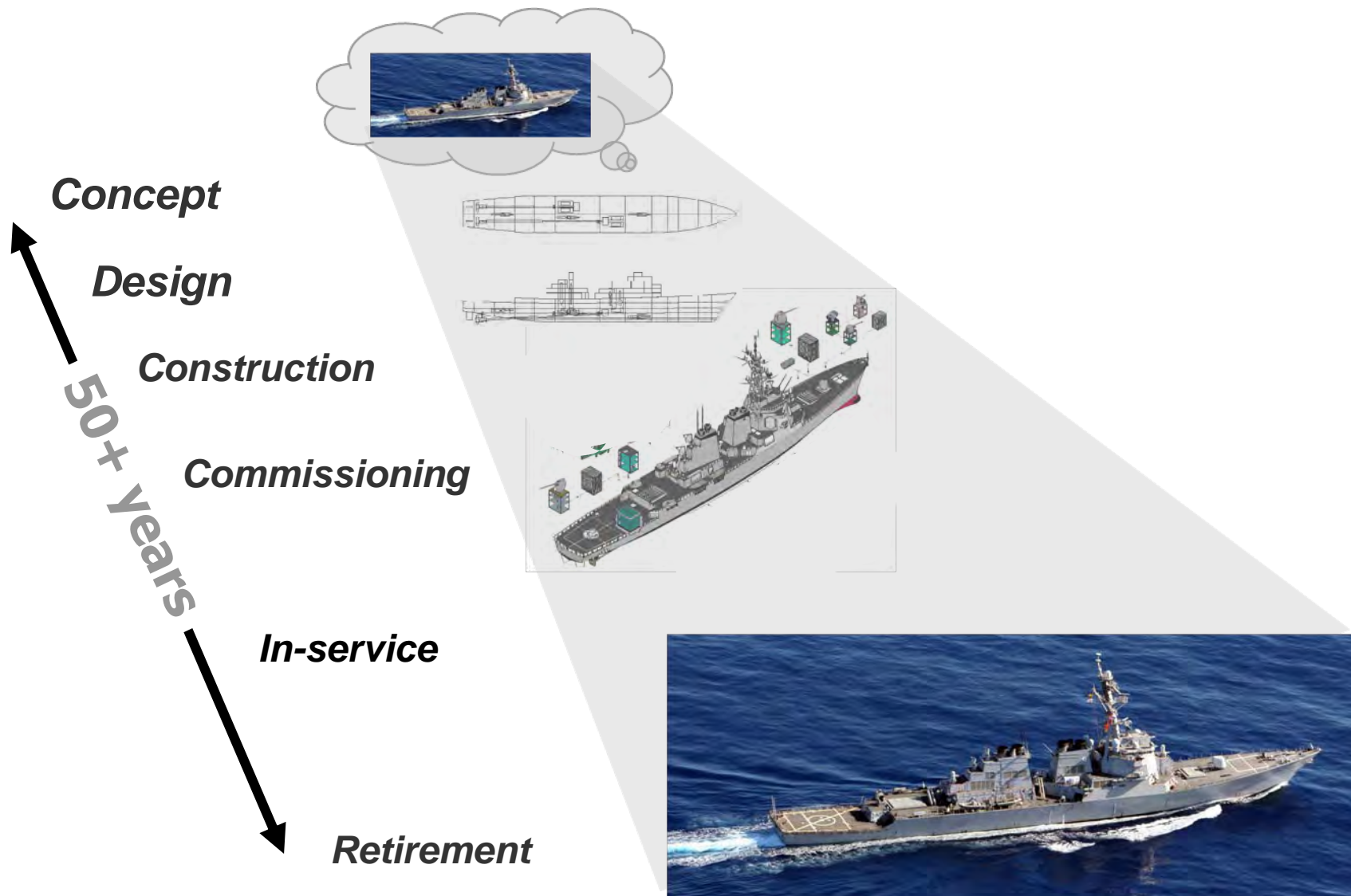
# Summary, up front

- **Navy warships are:**
  - Complicated
  - Highly integrated
  - Multi-mission
  - Designed by the Naval Sea Systems Command (NAVSEA)
- **Naval ship design involves:**
  - Large design teams
  - Long design schedules
  - Complicated acquisition procedures
- We are applying commercial process modeling techniques for:
  - **Better Management**
  - **Process Improvement**
  - **Tool Evaluation**
  - **Training**





# Warship Lifecycle



# Initial Motivation

- **We needed a method for prioritizing software development.**
- **How should scarce resources for software be spent?**
- **Where would the highest return on investment be achieved?**

We expected that a Ship Design Process Model would show:

- Where software was currently used;
  - Labor intensive activities;
  - Critical Paths; and
  - ROI.

## Typical Navy Surface Combatant DDG 51 Flight 1 Class Destroyer



**Length = 505 ft**

**Beam = 59 ft.**

**Displacement = 8,230 Ltons**

**Speed = 30+ knots**

**Crew = 276**

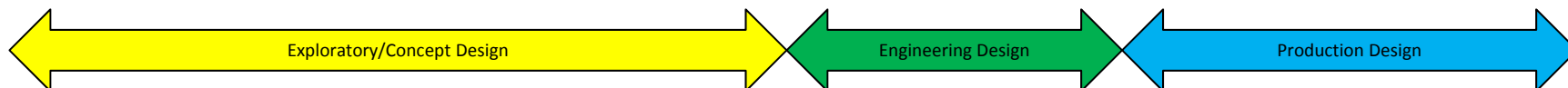
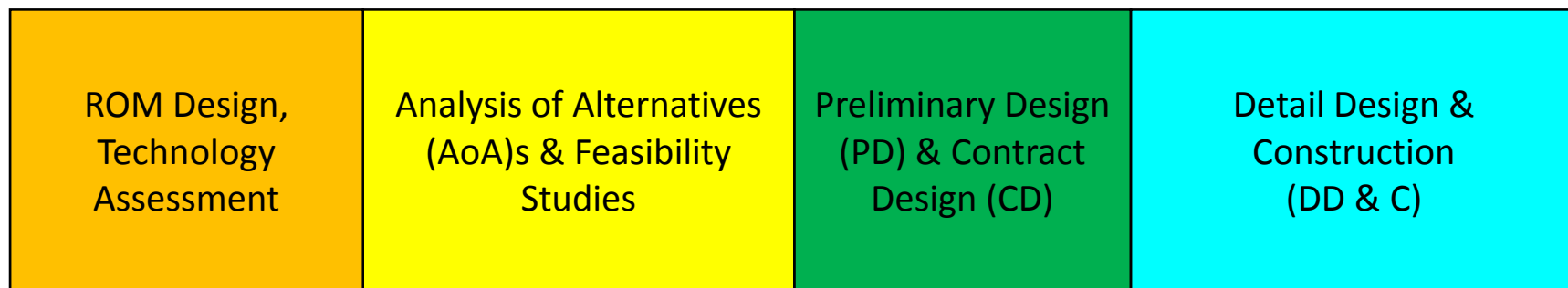
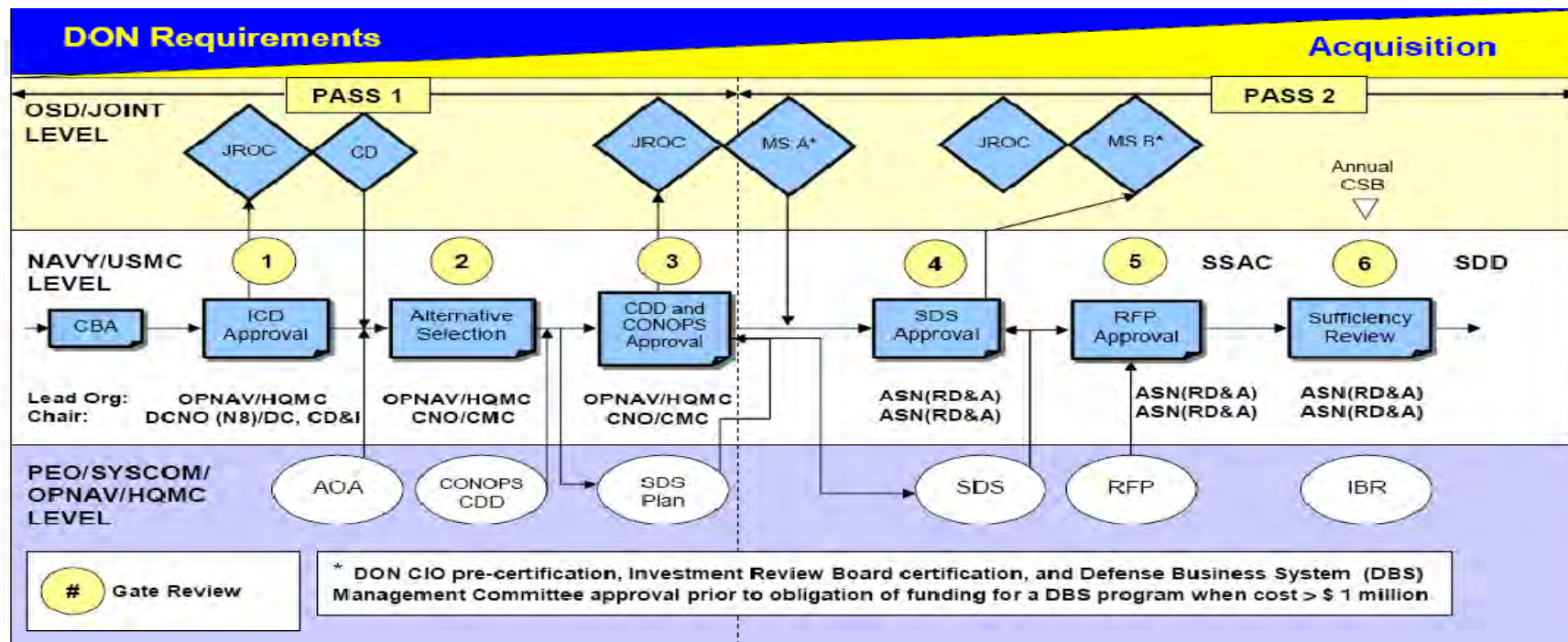
**Armament: Missiles,  
Torpedoes, Guns, Helicopters**

We modeled the design process for a conventional surface combatant because it was:

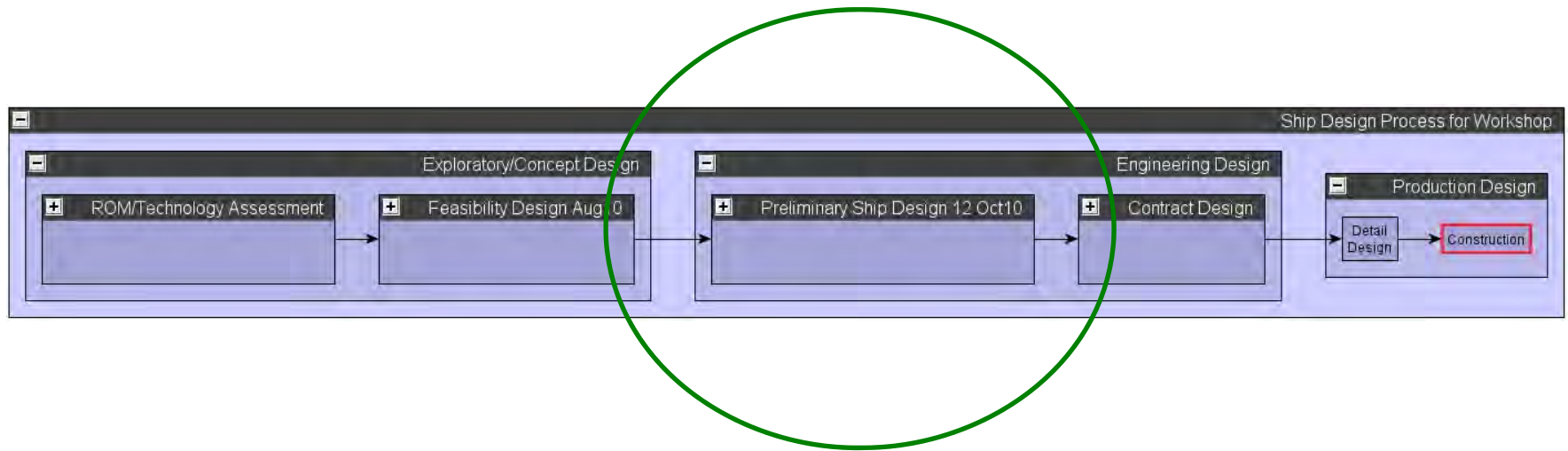
Sufficiently complex, but not as complex as an aircraft carrier;  
And it fit our organizational priorities.

<http://www.navy.mil/navydata/ships/destroyers/destroyers.asp>

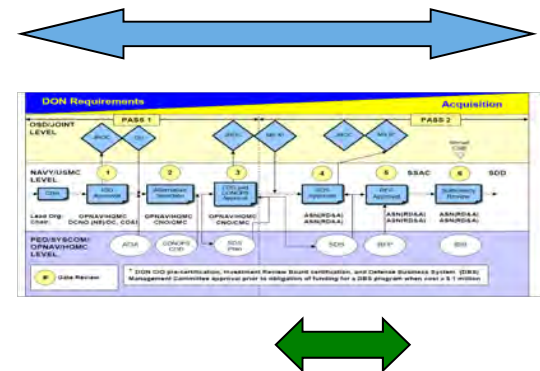
# Navy Ship Design and Acquisition Process



# An Integrated Model for the Entire Ship Design Process



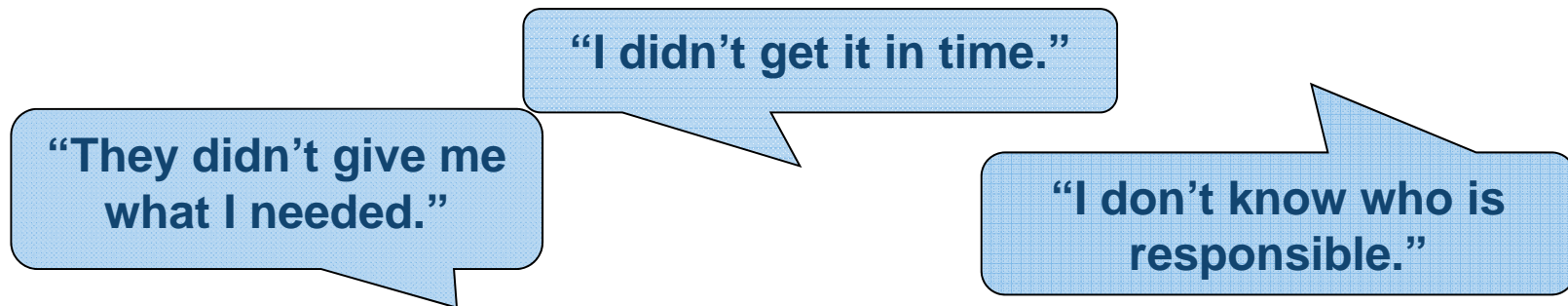
- We built a process model that could show all phases
- Initial efforts focused on Preliminary Design
  - Large number of participants
  - Many inter-related activities
  - High return on investment for improvements





## Interactions at all levels

- **Exchanges of information occur:**
  - Within Disciplines
  - Between Disciplines in the NAVSEA Organization
  - Between NAVSEA and NAVSEA Warfare Centers
  - With Contractors providing support at any level
- **Exchanges of information become more complex when organizations are under separate leadership.**
- **Dependencies between Activities = Implied Commitments**
- **Timeliness and Quality matter**



A process model defines commitments, enabling effective management.

# Our Process Modeling Objective

- **We set out to evaluate and prioritize new software development.**
- **We needed:**
  - Consistent understanding of where tools were used
  - Means for determining ROI
- **Developing a process model supported these objectives, and more . . .**
- **Our objectives expanded:**

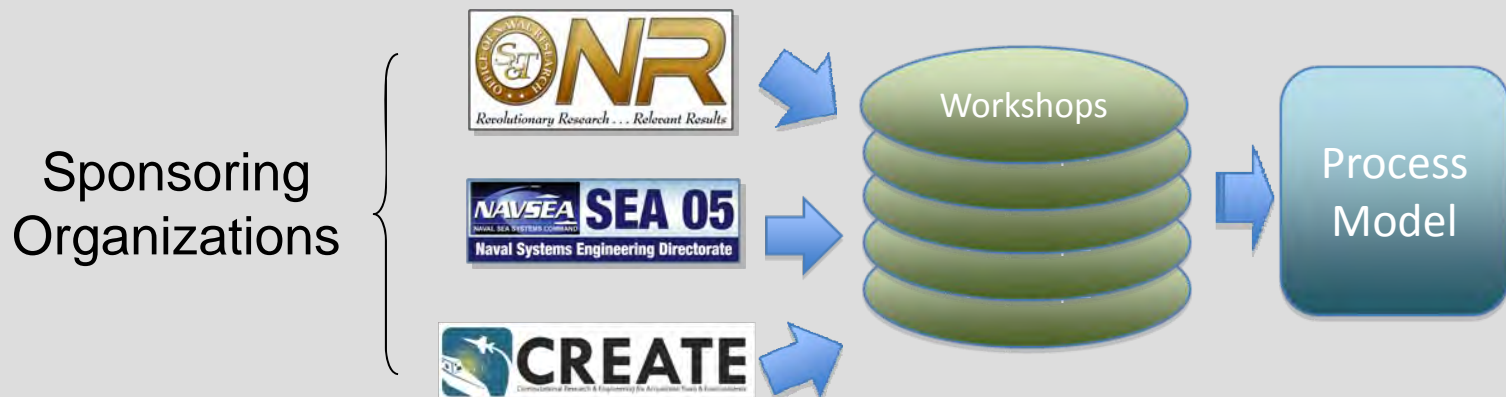


# Varied Understanding of Process

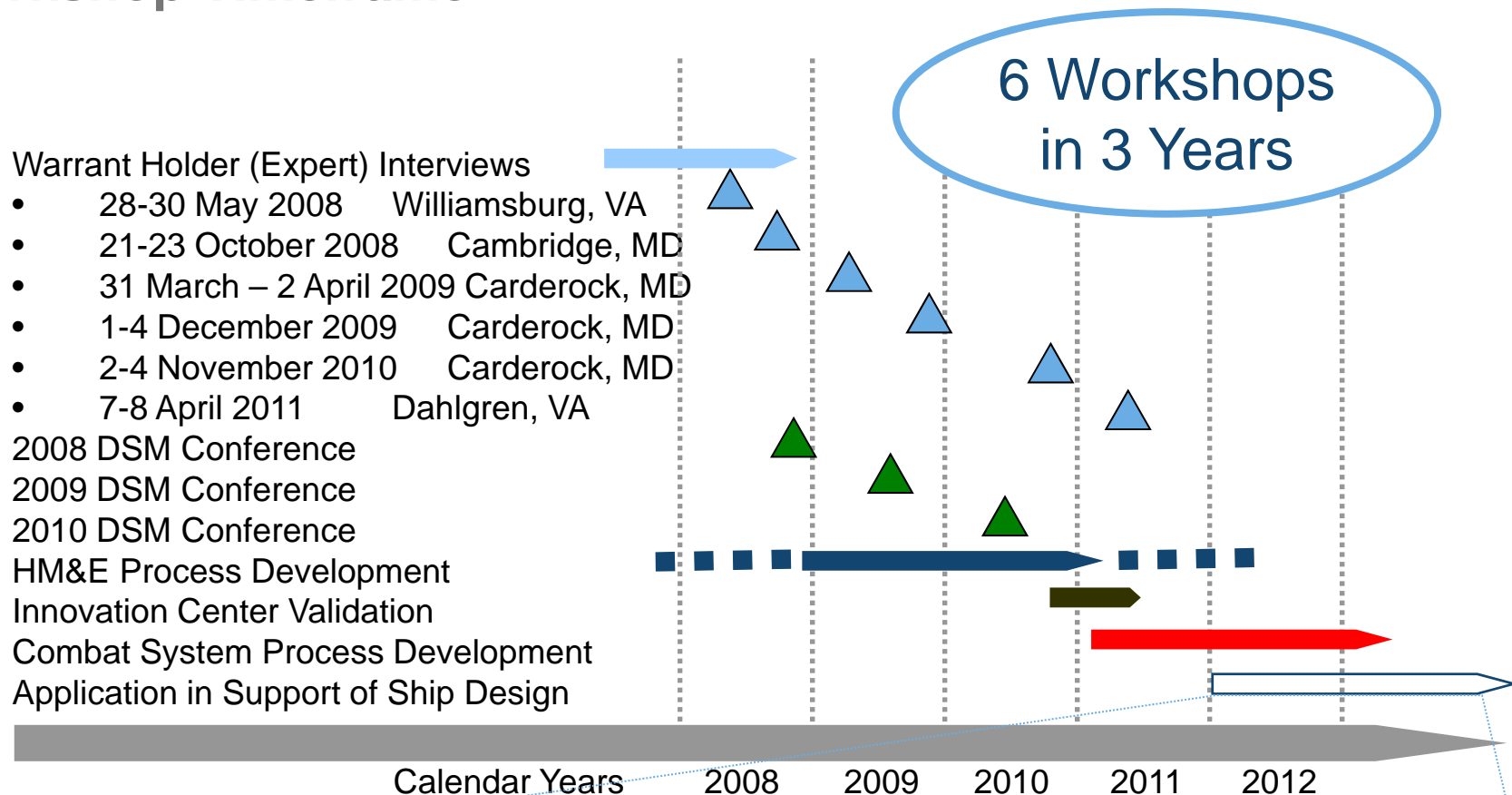
- We interviewed experts in specific technical areas.
- Some experts were not good at explaining their processes.
- If you cannot explain your process, how can you:
  - Discuss your role on the design team
  - Ensure you meet your commitments
  - Improve your process
  - Teach others about your process

?

We conducted semi-annual workshops to bring experts together.



# Workshop Timeframe



Discussing use of model in support of funded ship design projects.

Goal: Build Process Modeling Practice Based on Successful Application.



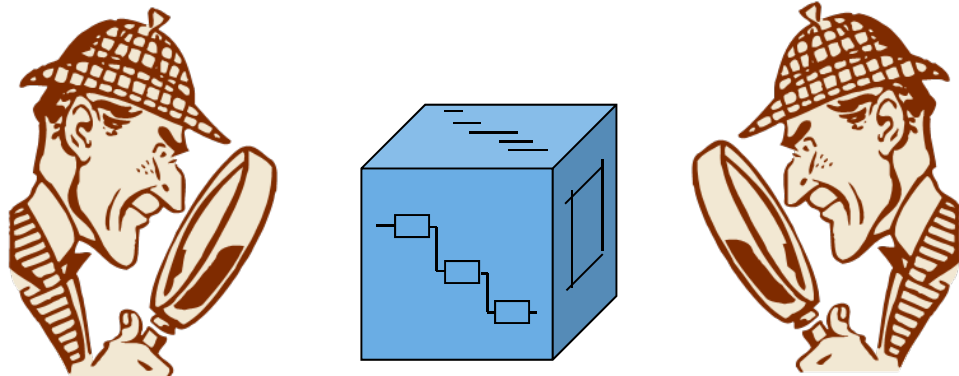
# Design Structure Matrix Methods

- We used Design Structure Matrix methods to capture process definition.
- For info on DSM, see: <http://www.dsmweb.org/>
- Workshop breakout sessions:
  - Experts brought together
  - Process activities identified; no need to worry about order
  - Dependencies identified
  - DSM put activities in order
  - Identifies highly interrelated clusters
  - Experts modified activities until satisfied
  - Deliverables and other details identified for each dependency

\$root	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Review and Interpret Requirements	1	.																				
Provide Susceptibility System Inputs (EXTERNAL)	2	1	.																			
Provide Recoverability System Inputs (EXTERNAL)	3	1	.	.																		
Evaluate Prior Phase (AoA) Designs	4	1	1	1	.	1																
Define Vital Systems and Spaces	5	1	1	1	1	.																
Input Hit Distribution (EXTERNAL)	6	1		1		.																
Add Design Detail where Required	7		1	1	1	1	.	4														
Conduct Trade-Offs	8		4		4	4	4	.														
Evaluate Shock	9	1	1	1	1	1	1	4	.													
Evaluate Holing	10	1		1	1	1	1	4	.	.												
Evaluate Whipping	11	1		1	1	1	4	.	.	.												
Perform Vulnerability Assessment (Modeling)	12	1		1	1	1	1	4	1	1	1	.										
Perform Damage Stability	13	1		1	1	1	1	4	1	1	1	.	.									
Prepare Cost Estimate Sheets	14			1			1	4					.	1								
Conduct Risk Assessment	15	1		1	1			4	1	1	1	1	1	.	1			1				
Generate Cost Estimates (EXTERNAL)	16													1	1	.						
Capture Uncertainty in Assessments	17	1				1	1	4	1	1	1	1	1	1	1	1	.					
Make Recommendations for Survivability Changes	18							4	1	1	1	1	1	1	1	1	1	.				
Report Vulnerability Results/Conclusions	19							4	1	1	1	1	1					1	1	.		
Develop Reliability Growth Plan	20	1													1	1			1	.		
Output Recoverability System Assessment	21			1				4	1	1	1	1	1		1		1	1		.		
Output Susceptibility System Assessment	22		1					4				1	1		1		1	1		.		

# Different People – Different Preferences

- **We need to view process data in multiple formats.**
  - DSM
  - GANTT Charts
  - “Boxes and Arrows” (IDEF)
  - Tabulated Data
- **The data must be consistent in all formats.**
- **We would like easy export to other applications**
  - Excel® files
  - CSV files
  - XML



# Integrated Process Model with Multiple Views & Interfaces

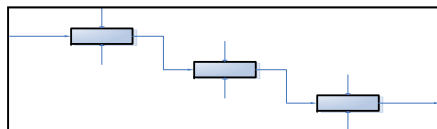
Task Name	Start	End	Duration
Task 1	1/1/2011	1/15/2011	14
Task 2	1/15/2011	1/30/2011	15
Task 3	1/30/2011	2/10/2011	11
Task 4	2/10/2011	2/25/2011	15
Task 5	2/25/2011	3/10/2011	14
Task 6	3/10/2011	3/25/2011	15
Task 7	3/25/2011	4/10/2011	15
Task 8	4/10/2011	4/25/2011	15
Task 9	4/25/2011	5/10/2011	15
Task 10	5/10/2011	5/25/2011	15

**Spreadsheets**



**Spreadsheet Software**

**Info Modeling Software**



**IDEF Diagrams**



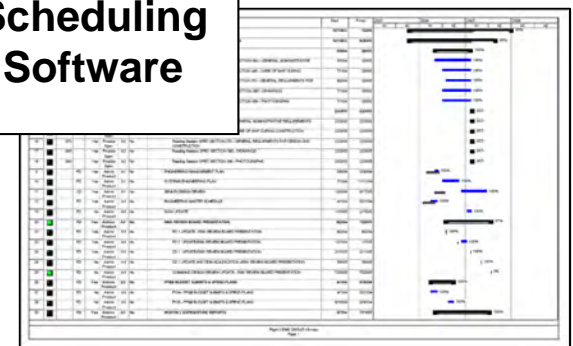
**Schema**

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Review and Interpret Requirements	1																					
Provide Susceptibility System Inputs (EXT)	2	1																				
Provide Recoverability System Inputs (EXT)	3	1																				
Evaluate Prior Phase (AoA) Designs	4	1	1	1	1																	
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Input Htt Distribution (EXTERNAL)	6	1																				
Add Design Detail where Required	7	1	1	1	1	1																
Conduct Trade-Offs	8	4	4	4	4	4																
Evaluate Shock	9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Evaluate Holding	10	1																				
	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	14	1																				
	15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	16																					
	17	1																				
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	20	1																				
	21		1																			
	22	1																				

**DSM**

**DSM Tool**

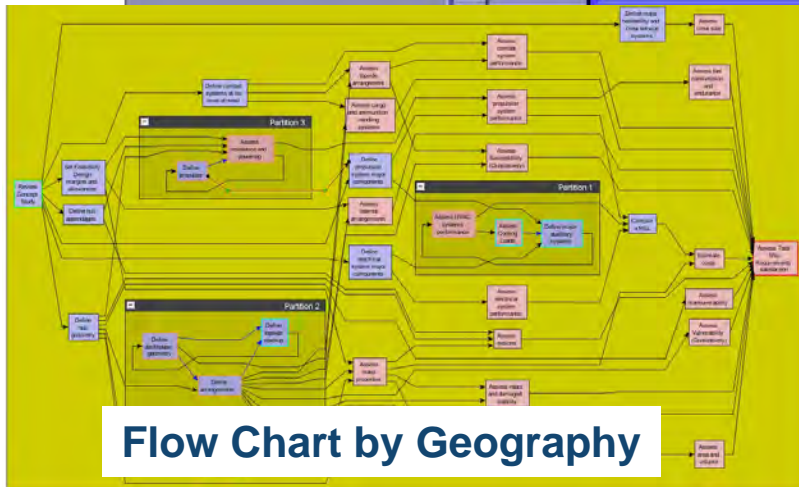
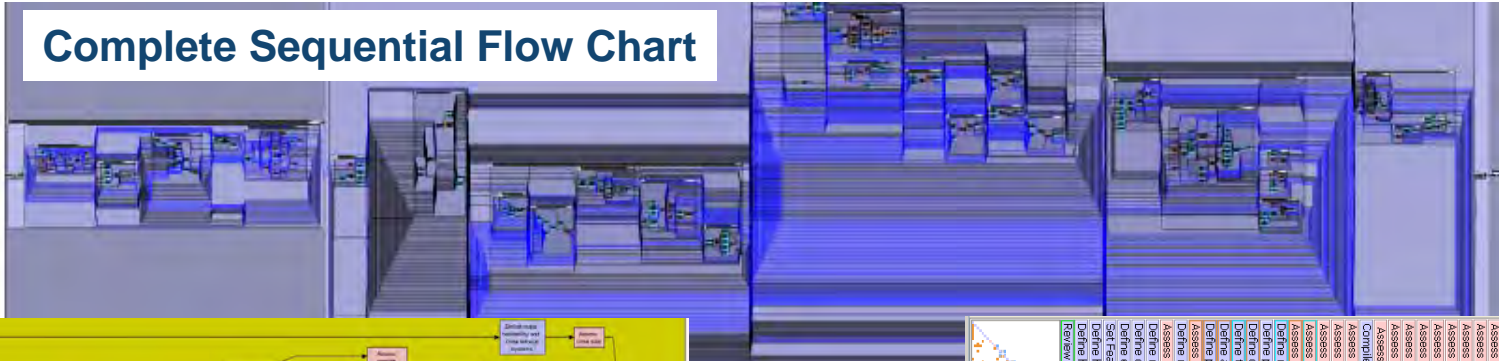
**Scheduling Software**



**Schedules**

# Different People – Different Preferences

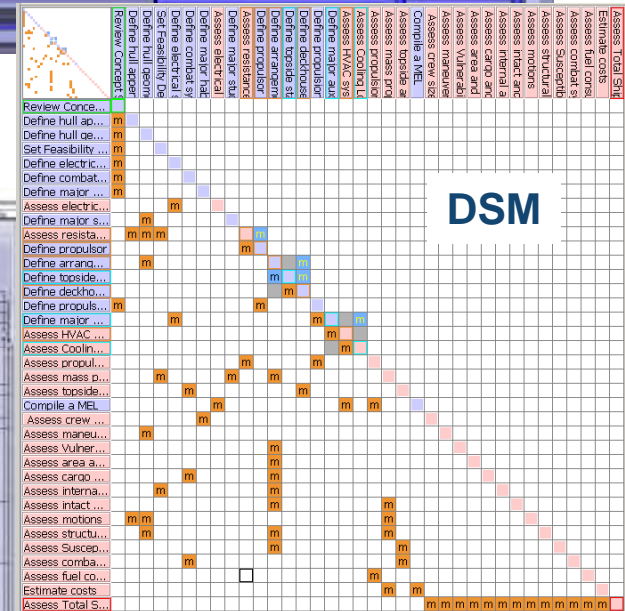
Complete Sequential Flow Chart



Flow Chart by Geography



Gantt Chart





# Multi-domain Views of Process

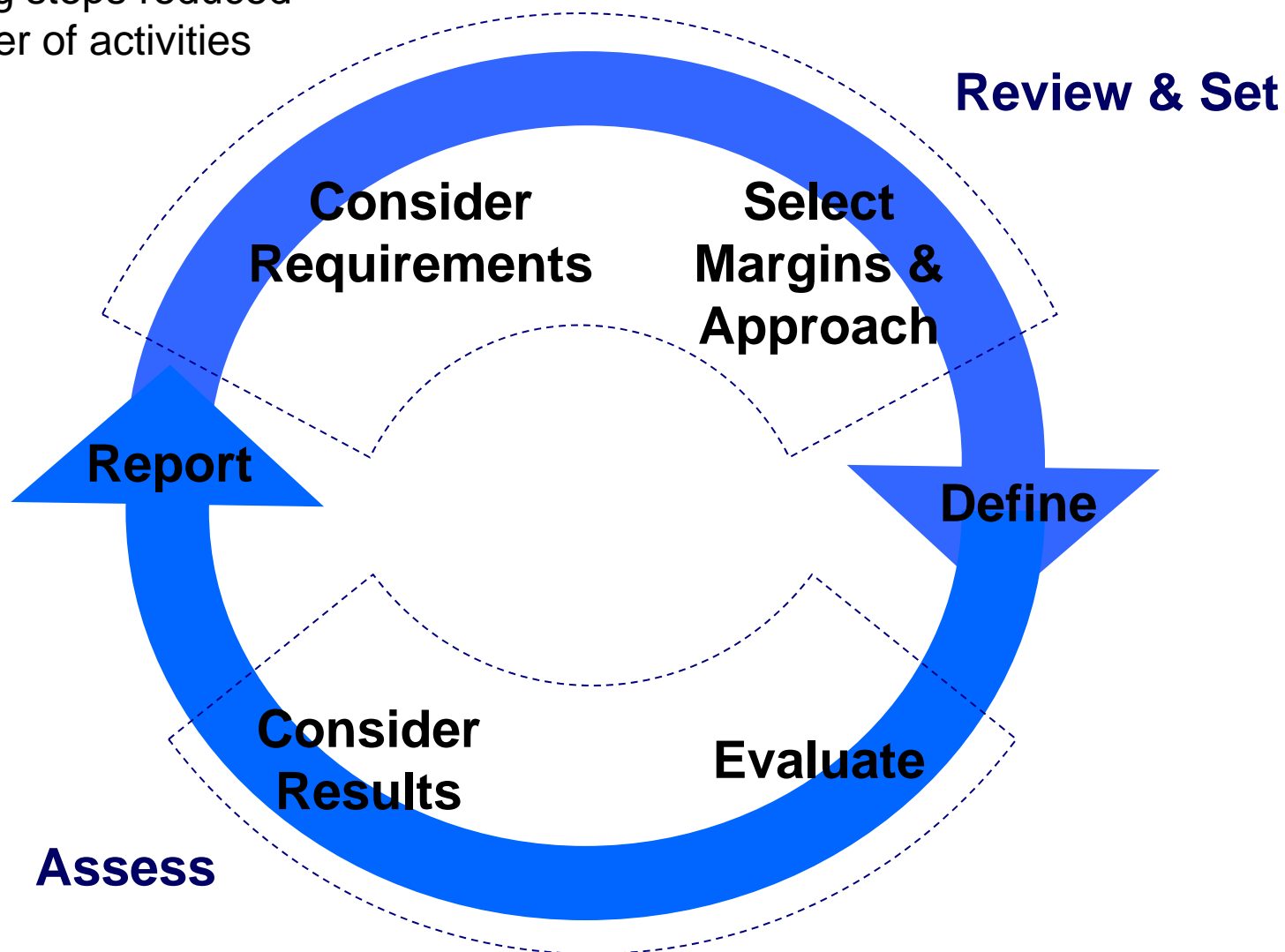
- **It is helpful to evaluate a project from multiple perspectives**
    - Process Order
    - Work Breakdown Structure
    - Organizational Responsibility
    - Geographic Location
    - Software Tools or Other Resource Dependency
  - **The model being developed can produce output organized by domains of interest**
  - **Examples:**
    - Division of Labor by Discipline
    - Critical Path
    - Organizational Distribution of Responsibility
    - Balance of effort by Worksites
- **Is your project collocated at the desired level?**
  - **Is there a participant on the Critical Path that is remotely located?**

# Complexity & Comprehension

- **No need to model infinite detail**
- **We estimated we could comprehend about 1,000 objects.**
- **Our Preliminary Design Model is comprised of:**
  - ~250 Activities
  - ~700 Dependencies
- **In practice, this has worked out to be just about right.**
- **Keeping major blocks to this size is a good rule of thumb.**
- **Several blocks are modeled.**
- **Other conventions are also important:**
  - Standard terminology or “Lexicon”
  - Consistent Terminology for Resources
  - Defined Start and Stop Activities (e.g. Design Reviews)

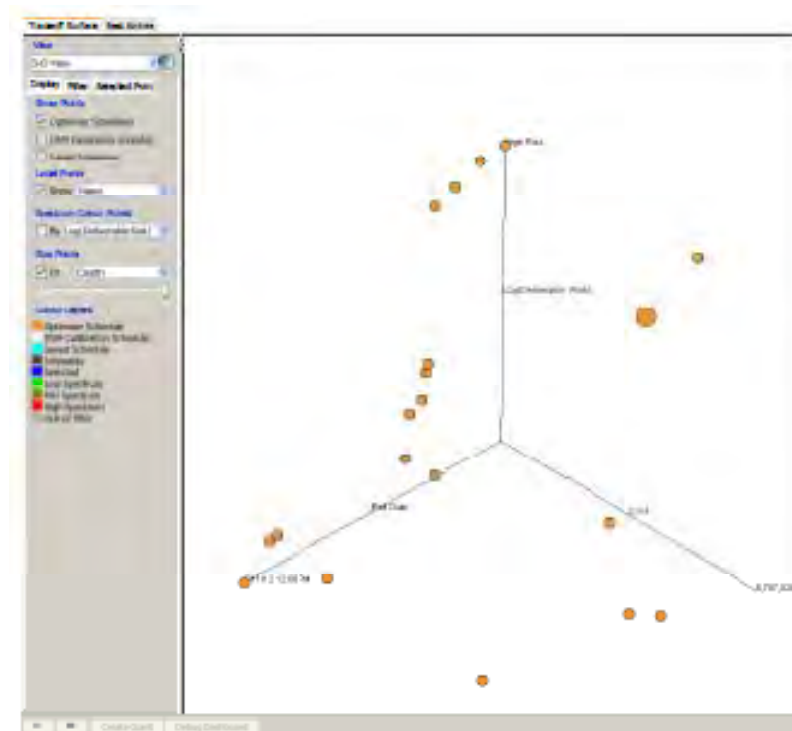
# Lexicon Hygiene – Standardized Nomenclature for Activities

Collapsing steps reduced the number of activities tracked.



# Process Simulation

- **The PLEXUS tool provides the benefit of process simulations.**
  - Explores trade-offs between Cost, Schedule, and Risk
  - Risk is reduced by iteration
- **We have only recently fully populated our model data and look forward to exploring the potential of process simulations.**





## Some Lessons Learned

- **It is difficult to improve processes you have not defined.**
- **Even the best experts struggle to describe their processes.**
- **COTS tools provide needed capability.**
- **Use Appropriate Level of Detail.**
- **Work at a consistent level of detail.**
- **Use Standard Lexicon.**
- **A process model provides means to capture expert knowledge.**
- **A process model is a training tool.**

## Other Plans

- 1. Expanding the scope of our model; working with other organizations to:**
  - Capture their process steps
  - Define process dependencies within the domain of the other agency
  - Define inter-dependencies with other agencies
- 2. Relating products to the high level DoD acquisition process**
- 3. Building a “practice”**
  - Not cost effective to train everyone in use of the model
  - Establishing small group of experts that assist in planning of new ship design projects, process improvement, software evaluation, or training
  - Naval Surface Warfare Center, Carderock Division (NSWCCD) is the home for this practice and trains young naval engineers.
- 4. Demonstrating effectiveness of model for new ship designs**
- 5. Applying risk and simulation capabilities**

# Summary

- **Complex engineering projects benefit from process models providing:**
  - A means for planning work
  - A way to evaluate alternative processes
  - ROI estimates for new software
  - Training of new employees.
- **Design Structure Matrix methods can be used to:**
  - Capture process definition in a facilitation setting
  - Provide insights into process complexity
  - Explore multi-domain relationships
  - Describe process activities and dependencies in a compact format
- **Commercial off-the-shelf process modeling software is available.**
- **Using standard nomenclature is recommended.**
- **The time and effort in process modeling is worthwhile.**

# APPLICATION OF PROCESS MODELING TOOLS TO SHIP DESIGN

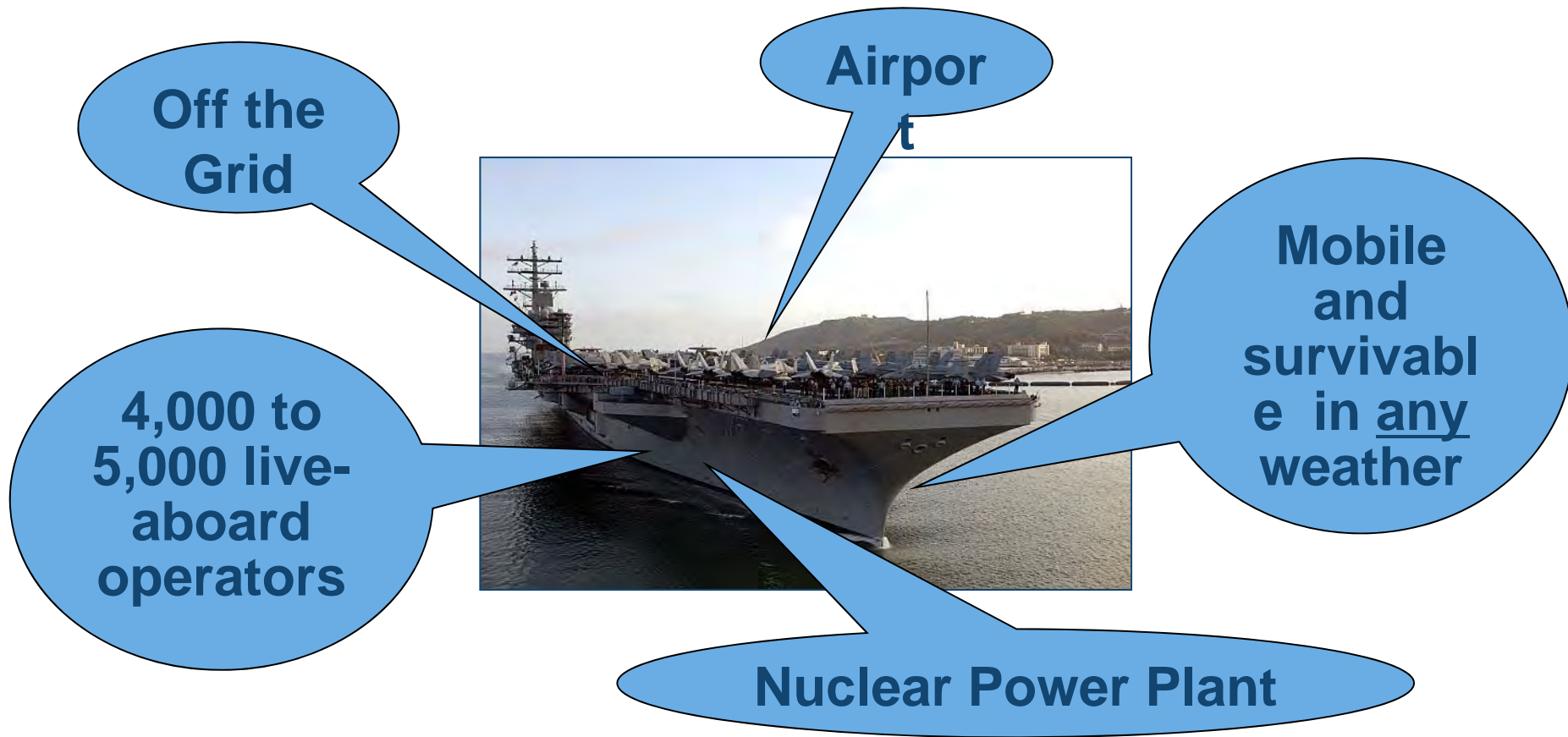
**CSC**

**Thank you very much.**

[dhelgers@csc.com](mailto:dhelgers@csc.com)



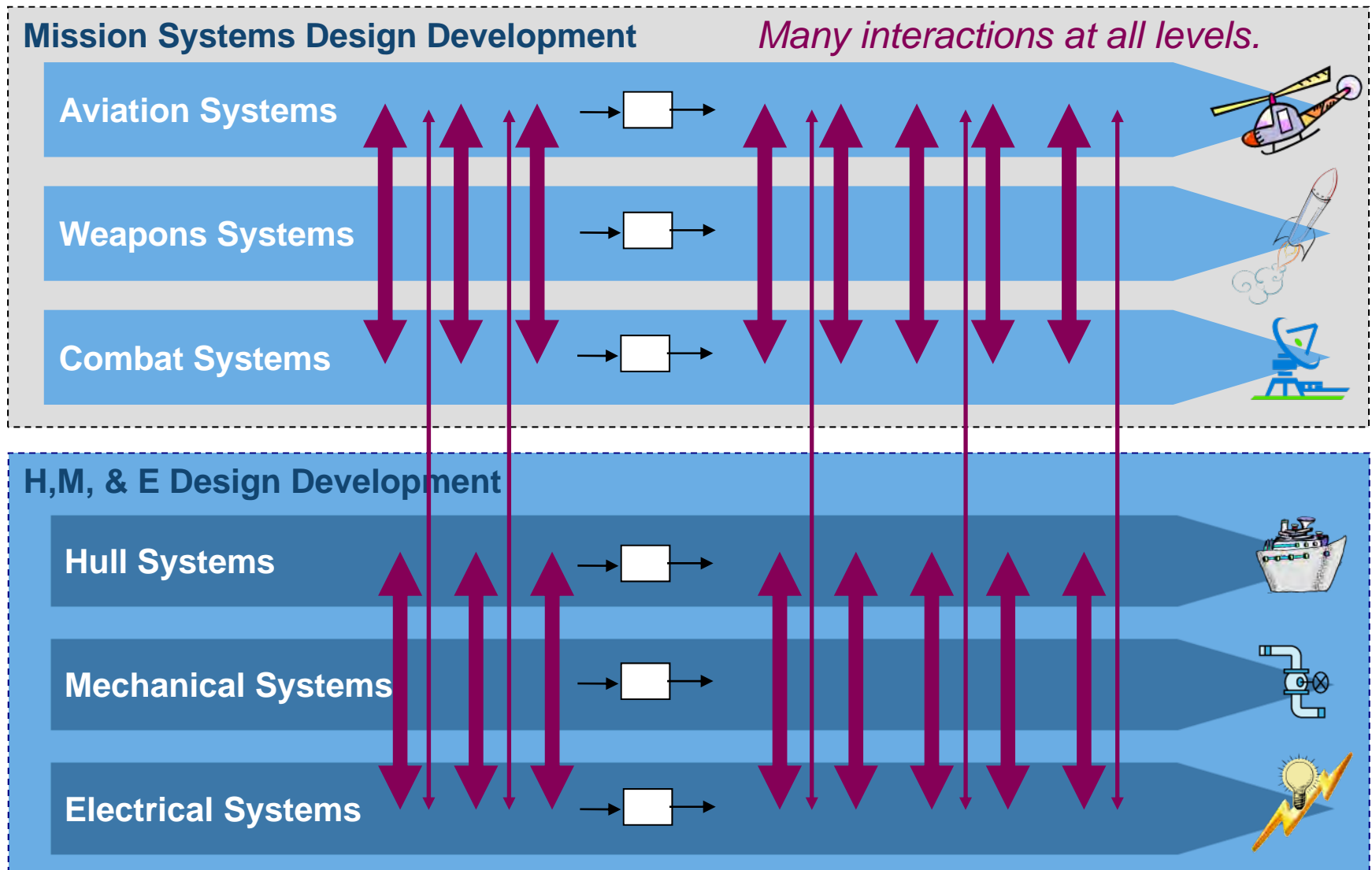
# Warship Complexity



Concept | Preliminary | Contract | Detailed Design & Construction  
10 to 15 year process →



# Complex Process Interactions



# Process Database Methods

- **Process order is important.**
- **Organizational structure is also important.**
- **Other factors to track:**
  - Work breakdown structure
  - Geographic location
  - Software required
  - Resources
  - Schedule
- **Need to track large amounts of data**
- **Prepared schema for process database**

**Planned to create a tool to model our process;  
Found COTS software that met our needs.**

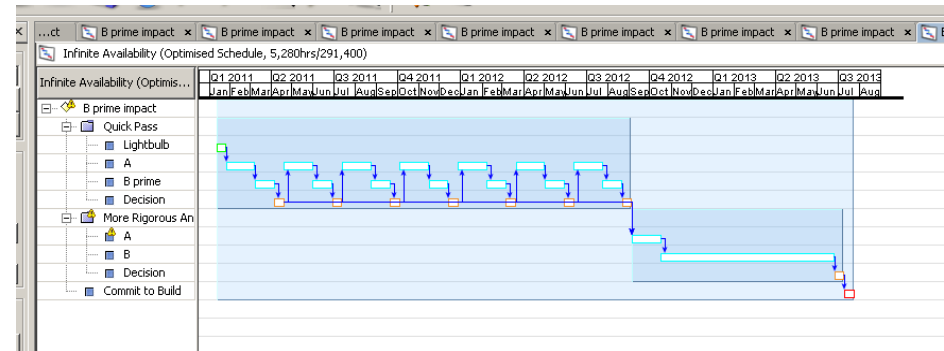
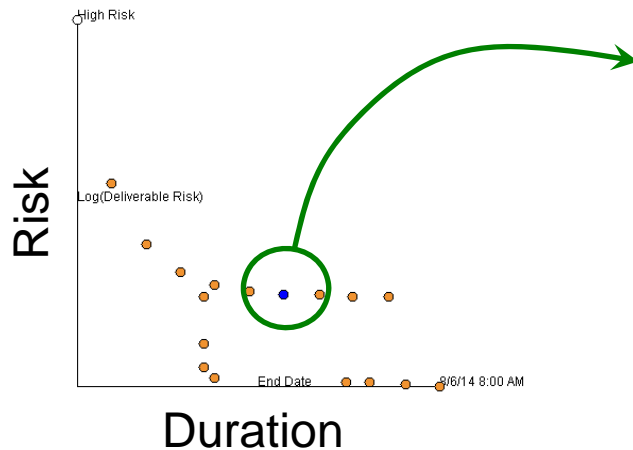
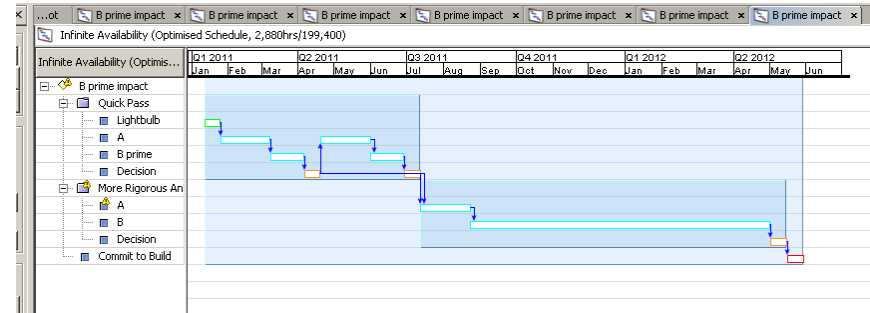
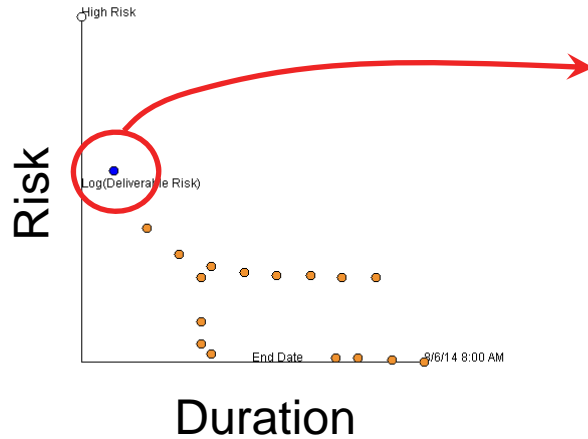
# Challenges

- **Organizational Resistance**
- **Individual Resistance**
- **Willingness and Ability to Support Process Modeling**
- **Lack of Current Process Definition**
- **Experts Not Articulate about Process Steps**
- **Complexity**
- **Imprecise or Ambiguous Language**
- **Investment**
  - Software Costs
  - Indirect Labor Costs
  - Schedule Availability & Priority

## Mitigation Strategy

- **Management Briefings**
- **Management Priority**
- **Independent Group Facilitating Process Modeling**
- **Workshop Facilitation**
- **Workshop Facilitation Provides Lexicon and Encouragement**
- **Capable Modeling Tools**
- **Standard Definitions & Lexicon**
- **Briefing Key Managers to build Support and Line Up Funding for FY12 and Beyond**
- **Installing software on server to provide broader access.**

# Risk Trade-Offs



Increased Iteration Decreases Risk Metric